



## Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact [support@jstor.org](mailto:support@jstor.org).

## Morphology of the flowers of *Zea Mays*

PAUL WEATHERWAX

(WITH PLATES 5 AND 6 AND FOUR TEXT FIGURES)

The structure of the maize plant presents a series of problems of a very special nature. Many of these have been thoroughly worked out from a purely morphological point of view, but it need hardly be said that the mass of economic information about corn almost obscures the part that may be considered purely botanical. Of the special morphology of the plant probably no part has received less thorough treatment, in proportion to its importance, than that pertaining to its floral parts. It is true that many studies have dealt in a way with this phase of the subject, but it has almost always been in connection with some more extended study and has, consequently, been superficially treated. The result is that one looks in vain through botanical literature for a complete and well-illustrated discussion of the structure of the maize flower.

The investigations upon which this work is based have extended over a period of almost two years, during which time representatives of all the six subspecies of *Zea Mays* have been under observation to a greater or less extent. The greater part of the work has been done upon different varieties of sweet corn, but the other five types have also been examined, especially where any variation from the sweet corn type of flower was apparent. All the available literature has been consulted, and most of the points made therein have been verified.

It is not intended here to present a group of facts that are entirely new. The available data, widely scattered, have been collected, and some changes and additions have been made, together with an attempt to illustrate fully wherever an illustration will emphasize a point or convey the meaning more clearly.

I desire to express my obligations to Professor D. M. Mottier for valuable suggestions and criticisms pertaining to this work,

and to a number of friends who have supplied me with seed of some of the varieties of corn used.

#### INFLORESCENCE

In the typical case the male and female inflorescences are borne on separate parts of the same maize plant, the former being the tassel and the latter the forerunner of the ear. Exceptions to this separation of the two types of flower sometimes occur and will be discussed later.

The male inflorescence is a broadly expanded panicle, often more than a foot in length, and made up of a central axis and several spreading rachids. Upon each rachis and the central axis the spikelets are arranged in pairs or, more rarely, in groups of three or four; one spikelet of each group is usually pedicelled, while the others are sessile.

The female inflorescence is a thickened spike, later to develop into the ear with its woody cob. Upon the axis of this inflorescence are borne a number of double rows of spikelets, the rows being double because of the pairing of the spikelets, and from these are produced an even number of rows of grains. Normally the minimum number of rows is eight, and it may vary in even numbers from this to twenty-four or more. The whole female inflorescence is enclosed in the husks, which are modified leaf sheaths borne upon the short branch that bears the ear.

It is very probable that the ear has developed from a primitive bisexual inflorescence, which had a structure similar to that of the male inflorescence of the plant at the present time; but Harshberger (1) and Montgomery (2), who have made extensive studies of this, disagree as to how this step actually took place, the one holding that the rachids of the primitive inflorescence united to form the ear, and the other maintaining that it was only the central spike of the tassel that persisted. Good arguments are found to support each view, and some other evidences not mentioned by either of the above, but having an important bearing upon the question, are now under observation and will be made the subject of a future report.

The normal male inflorescence of the plant at the present time is generally believed to have resulted from the suppression of the pistils of the hermaphrodite flowers of the primitive inflorescence.

## STAMINATE FLOWER

The male spikelet contains, either functional or in rudimentary form, all the parts of the typical grass spikelet. It is normally two-flowered. A few one-flowered spikelets have been observed, but they usually contain a second flower in an undeveloped condition. At the ends of rachids, spikelets with more than two flowers are sometimes found, but they are probably to be understood as being two or more two-flowered spikelets combined.

Completely enclosing the rest of the spikelet before maturity are the two rather firm, taper-pointed, empty glumes, having a varying number of nerves and thickly beset, as is the rachilla below the glumes, with short, stiff bristles. The lower glume overlaps the edges of the upper and has the lower point of insertion upon the rachilla (FIG. 1). The flower is in the axis of the thin, membranaceous, blunt-pointed, two- to four-nerved lemma or flowering glume, and subtended by the palea, which has a similar structure except that it is regularly two-nerved. No trace of a continuation of the rachilla has been observed between the paleae. On this basis, then, there is no indication that the normal spikelet was ever more than two-flowered. The rachilla is jointed just below the glumes.

In so far as was observed, the two flowers are identical in structure, but the upper one is the first to mature. During microspore development the anthers of the upper flower are often found with the tetrad stage or with the pollen grains rounded off, while those of the lower flower show resting or synaptic stages; but the pollen grains of the younger flowers are usually rounded off and apparently mature before the older flower puts out its stamens.

The three stamens of each flower are so arranged that their points of attachment form the vertices of a triangle which has one of its bases toward the palea. Midway between the two lateral stamens is the rudiment of a pistil. Next to the lemma,

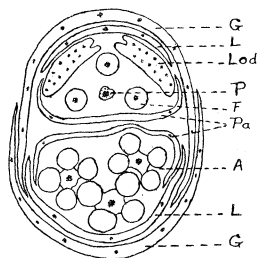


FIG. 1. Transverse section of lower part of staminate spikelet of Country Gentleman sweet corn,  $\times 20$ . G, glumes; Lod, lodicule; F, filament of a stamen; A, anther; L, lemma; P, rudimentary pistil; Pa, palea.

and outside the triangular area to which the stamens and rudimentary pistil are attached, are the lodicules (FIG. 2 and TEXT FIG. 1).

The immature stamens have short, stiff, and rather fleshy filaments, which become long, thin, and flexible in anthesis, allowing the anthers to hang well below the rest of the spikelet (compare FIG.

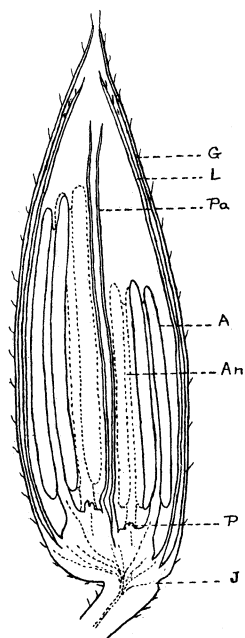


FIG. 2. Longitudinal section of staminate spikelet of Country Gentleman sweet corn,  $\times 15$ . G, glume; Pa, palea; An, position of one of the lateral anthers; L, lemma; A, dorsal anther; P, rudimentary pistil; J, joint of rachilla.

1 with FIG. 2 and with TEXT FIG. 2). The arrangement of the stamens in the flower seems to have nothing to do with the position that they will occupy in anthesis, all three sometimes falling from one side of the spikelet, or two from one side and one from the other as determined by external conditions. The immature anther has four loculi, which later form two "cells." The anther cells open by short slits and allow the pollen to sift out (FIG. 1).

The thick, fleshy lodicules do not show the scale-like structure that often characterizes them in other grasses. Along the top of each there is a deep, rounded groove with irregular sides. The lodicule is well supplied with vascular tissue, transverse sections showing ten or twelve relatively large, well-distributed strands (TEXT FIG. 1). As the flower matures, the lodicules increase in size and push back the lemma and glume, thus opening the spikelet.

In the literature examined, the only mention of a pistil in a male flower is by Baillon (4, p. 325) and Bentham and Hooker (5, p. 1114), both of whom, however, say that it is not present. They treat the normal flower as being wholly staminate in structure as well as in function; but the rudimentary pistil, a very inconspicuous body, to be sure, has been found in every staminate flower that I have examined. Its development has not yet been worked out; but it is known that long before anthesis its growth stops, and, during the greater

part of the development of the rest of the flower, the pistil shows evidences of disorganization, especially by its manner of taking stains.

The vascular system of the base of the spikelet has not been thoroughly worked out, but strands have been traced to most of the organs, including a large one to each lodicule and a rudimentary one to the abortive pistil.

#### PISTILLATE FLOWER

The available descriptions of the female spikelet and flower are much better than those of the homologous parts of the male inflorescence. This is largely due to the fact that several investigators have, in dealing with embryological features, found it necessary to discuss the developing caryopsis in relation to the other parts of the spikelet. However, since much of the work on the structure of the spikelet and flower has been merely incidental to other lines of investigation, many inaccuracies have found their way into the recent works.

The pistillate spikelet is two-flowered, and its parts are, in number and arrangement, similar to those of the staminate spikelet, allowing, of course, for the functioning of a pistil instead of stamens and the abortion of certain other parts.

The empty glumes are rather thick and fleshy and do not completely enclose the other parts, except in pod corn, at any time during the development of the spikelet. The hairs that are present on the glumes of the male spikelet are here represented by similar ones around the edges and by pits scattered over the surface of the glumes. The rachilla is jointed just below the base of the glumes (FIG. 3). The lemma and palea are shorter and thinner than the glumes. These floral bracts cease to develop, in most varieties, about the time of fertilization and remain around the base of the fruit, forming the red or white more or less chaffy covering of the cob. If fertilization is prevented, they may grow to three or four times their normal size. In the pod corns the floral bracts, especially the glumes, become herbaceous and continue to grow after fertilization and are ultimately found completely enclosing the mature fruit.

In most varieties of maize the two flowers of the female

spikelet are quite different in function and detailed structure, the lower one being aborted; and the descriptions of the two must be dealt with separately. There are certain important exceptions, however, to this peculiarity of the lower flower, and these will be discussed later.

The functional pistil occupies a normal position between the lemma and palea of the upper flower (TEXT FIG. 3). It is readily

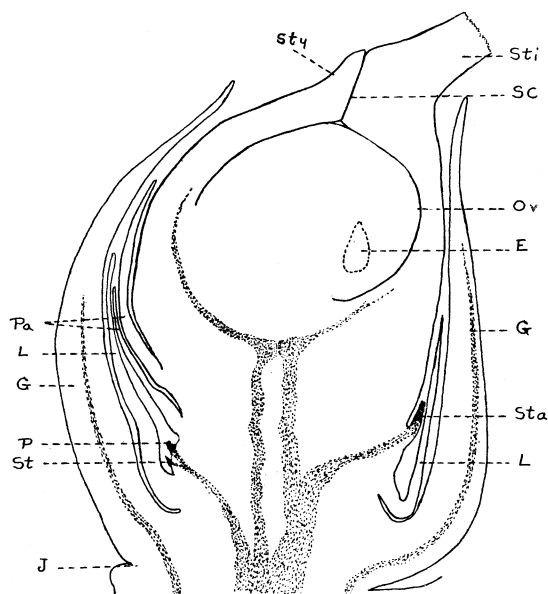


FIG. 3. Longitudinal section of pistillate spikelet of Black Mexican sweet corn,  $\times 25$ . *Sti*, base of stigma; *Sty*, style; *E*, outline of embryo sac; *L*, lemma; *Pa*, palea; *St*, stamen of aborted flower; *SC*, stylar canal; *Ov*, functional ovule; *G*, glume; *Sta*, rudimentary stamen; *P*, pistil of aborted flower; *J*, joint of rachilla.

seen to consist of two parts, the bulb-shaped lower part, later developing into the caryopsis, and the long "silk" extending beyond the husks.

The accurate naming of at least one part of the pistil seems to have received little attention from recent writers. Harshberger (1, p. 400) speaks of the silk as a long, hairy style, and later adds that the style is hairy to entrap the round, smooth pollen grains. Hunt (6, p. 146) speaks of it as the "style, commonly known as the 'silk.'" Baillon (4, p. 325) and Bentham and Hooker (5, p. 1114)

give similar descriptions and call the silk a style. Only one dissenting opinion has thus far been noted, and that in Wood's (7) text-book, published about 1870. Here (p. 48) he figures the pistil of *Zea* and mentions its long, filamentous *stigma*.

All evidences indicate that the silk is stigmatic, at least in a rudimentary way, even to its base. The hairs are most numerous near the tip but are to be found all along the organ. Crozier (8) has noted that silks that have been repeatedly cut off are still capable of being pollenized, showing that it is not the forked tip alone that is stigmatic. Of course the part of the silk that is protected by the husks does not, under ordinary conditions, become a germinating place for pollen, but continued growth is always exposing parts that were previously covered. How long this might continue is not limited by any visible structural difference, and it is probable that pollen will germinate on any part of the silk. Even those who persistently call it a style admit that the silk catches the pollen grains and furnishes them a place to germinate, and this is by definition the function of a stigma. In cross section the silk has the shape of an asymmetrical figure eight (FIG. 8). This appearance is due to a longitudinal groove extending along both the adaxial and abaxial sides. The abaxial groove is deep and narrow, and the one on the adaxial side is broad and shallow (FIGS. 6-8). Near the tip these two grooves unite, making the silk unequally two-pointed (FIG. 5). A strand of vascular tissue traverses each side of the silk and continues into the tip after the silk divides. In distribution the hairs are limited to the edges and adaxial side (FIGS. 6-8), being more numerous, as has been said, near the distal extremity of the silk. If the two stigmas of the typical grass flower should unite for almost their entire length, the organ formed would be, except for relative length, not unlike a corn silk. It seems wholly consistent, therefore, to consider the corn silk a compound stigma.

Just what course the pollen tube takes with reference to the parts of the pistil is not definitely known, but growth of the tube causes the stigma to dry up. Silks that have been protected from pollen may, however, as Crozier (8) has pointed out, remain fresh for many days and continue to grow in length.

If the silk is to be considered a stigma, then the style is the



short protuberance at the top of the ovary, to one side of which the stigma is attached (FIGS. 3 and 4 and TEXT FIG. 3). The style is traversed by a tubular opening leading from the surface to the interior of the ovary (FIGS. 3 and 4 and TEXT FIG. 3.) This canal is especially prominent in young stages of ovarian development and never quite disappears. It has been termed the stylar canal by practically all that have had occasion to mention it, even by some of those that call the silk a style. Whether or not the pollen tube traverses this canal on its way to the ovule has not been determined.

The ovary is thick-walled and contains a single large, anatropous ovule. The embryo-sac is near the upper side, with reference to the cob as an axis, and the embryo is developed on that side of the caryopsis. The detailed structure and development of the ovary properly belongs in another connection and has been worked out by True (9, p. 212), Poindexter (11, p. 3), Guignard (10, p. 2), and others.

Just below the ovary, and somewhat irregularly spaced around the circumference of its support, are three small, rudimentary stamens (FIG. 4 and TEXT FIG. 3). They have a yellowish, wrinkled appearance and stain like disorganizing tissue. Baillon (4, p. 325) makes mention of "stamina 3 (in flore foemineo ad staminodia vix conspicua reducta," but Bentham and Hooker (5, p. 1114) dismiss the question with "staminodia o." The other works that I have examined make no mention of these rudimentary stamens.

In the normally functional flower of the female spikelet the lodicules are, in so far as I have observed, entirely lacking. Montgomery (2, p. 61) has noted the same fact.

The aborted flower is much more simple in structure than the functional one just described. It is located between the lower lemma and palea, and, because of the suppressed development of its basal parts, it appears to be on the side of the pedicel that supports the functional flower (FIG. 4). In other words, the functional flower appears to terminate the rachilla, while the aborted one seems to be laterally attached; but there is no real evidence that either flower is morphologically at the end of the rachilla.

The male and female parts of this aborted flower make about equal development, the stamens being about as well developed as those of the functional female flower, and the pistil resembling that in the normal male flower. The lodicules are also present and pretty well developed (FIG. 9).

Sturtevant (12) reports that he found on one occasion an ear of pod corn that had the kernels "twinned in the pods." In several ears grown from seed furnished by Professor M. L. Fisher, of Purdue University, I have found a few pods each of which had two grains (FIG. 12). Examination of these shows that both flowers of a spikelet have developed. Kempton (14, pp. 8 and 9) reports the same occurrence in a few spikelets of a variety of corn grown by the Hopi Indians of Arizona and adds that the lower flower in several varieties occasionally develops, sometimes accompanied by the abortion of the upper flower. In the summer of 1914, while preparing material for study, I found that the variety of sweet corn known as Country Gentleman regularly has both flowers of the female spikelet functional. Stewart (13) has recently reported an observation of the same kind.

In this variety, then, two grains are produced where there is only one in most other varieties, and the ear has practically the double number of grains. On account of this the grains are so much crowded that they become long and slender (FIG. 13) and are thrown out of line so as to appear to be no longer arranged in rows (FIG. 14). Kempton (14, p. 8) speaks of one variety of sweet corn that shows an exception to the usual rowed arrangement of the grains, but he attributes the irregularity to an indiscriminate arrangement of the spikelets. The variety is not named, but, even to the "shoe peg" type of grain produced, it might be "Country Gentleman," except for the arrangement of the spikelets. I have found no variety of corn in which the spikelets were not arranged in rows on the cob.

In appearance and structure this functional lower flower of "Country Gentleman" sweet corn is similar to the upper one, but it is often somewhat smaller and slower to mature (TEXT FIG. 4). With reference to their position on the cob as an axis, the arrangement of the parts of this flower is, as might be expected, the exact opposite of that of the upper flower. This causes the stigma to

make a sharp bend near its base in order to take its proper direction of growth toward the tip of the ear (TEXT FIG. 4). Because also of this opposite arrangement of parts, the embryo develops on the abaxial side of the grain, and, in following a row, we find the alternate grains with their embryos turned toward the base of the ear, a thing that does not occur in the ordinary ear. This same pairing of the kernels with reference to the position of the embryos is noted in the pod corn that occasionally produces two grains in a pod.

An interesting suggestion as to the probable evolution of this peculiarity in this variety of sweet corn is offered by the fact that

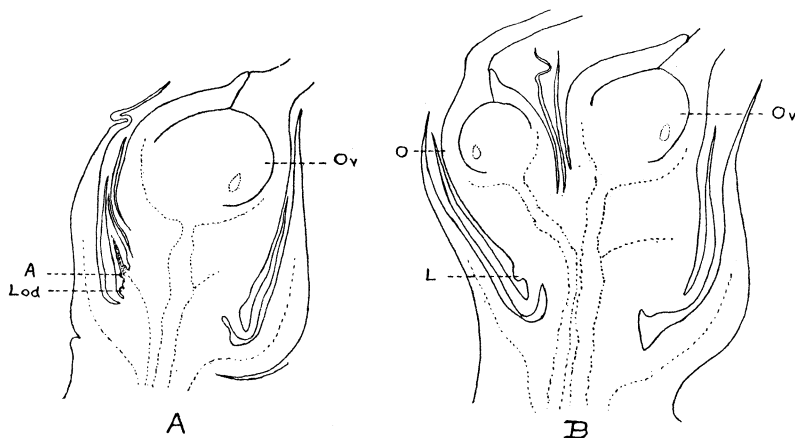


FIG. 4. Longitudinal section of female spikelet of Black Mexican sweet corn (A) and of Country Gentleman sweet corn (B),  $\times 12$ . *Ov*, functional ovule; *O*, ovary that usually does not develop, except in Country Gentleman sweet corn; *A*, aborted flower; *Lod*, lodicule. (The lodicules are really lateral organs, but, when rudimentary, they are often sufficiently out of place to show in a median section.)

in the lower flower rudimentary lodicules are present as in the aborted flower of other kinds of maize. If the spikelet with two functional female flowers is the primitive one from which the other type has been developed by abortion of the lower flower, why should only one of the flowers retain its lodicules? It seems rather more probable that the second functional pistil has resulted from the development of the rudimentary one in the aborted lower flower of the typical female spikelet. In support of this belief may be added the fact that the lodicules of the functional flower

seem to be smaller and less developed than those of the aborted flower. This question will, however, bear further investigation.

#### POLLINATION

An unusually large number of interesting correlations are found between structure and function as applied to pollination. Practically the only means of pollen transfer are gravity and the wind. A few insects may work upon one or the other of the inflorescences, but none have been observed that find it profitable to visit both.

The most noticeable correlation, and one that sheds much light upon the probable course followed in the development of monoecism, is in the position of the male inflorescence above the female this tending to render functionless the ovaries in the tassel and the pollen in the lower inflorescence of the primitive ancestor of the maize plant.

The pollen is fine and light and easily carried by the wind. Each individual grain is smooth and dry on the outside and not well adapted to adhering to anything except something of the feathery nature of the stigma. Thus a minimum amount of pollen is lost by adhering to the leaves and stem above the female flowers.

Of course much pollen is lost by any plant that depends upon the wind for pollination, but ample allowance is made for this in maize. Lazenby's estimate for a dent variety shows that about 45,000 pollen grains are produced for every ovule; and Sargent estimates that the ratio is at least 9,000 to 1. These figures are reported by Hunt (6, p. 146). In a variety of popcorn that I have examined, the number of male spikelets produced is approximately the same as the number of female spikelets, the variety having an average of three ears to the stalk. But each female spikelet produces one ovule, while the six anthers of a male spikelet produce no less than 15,000 pollen grains. Since most varieties have a larger tassel and a smaller number of ears than this one, it is probable that this ratio of 15,000 pollen grains to 1 ovule is low enough.

The idea is held by many that self-pollination is prevented by the shedding of the pollen before the maturity of the stigmas

of the same plant, but such is not the case. Hunt (6, p. 146), Harshberger (1, p. 401), Collins (15, p. 3), and others say that self-pollination is possible, and my own observations are in accord with their conclusions. In securing pure lines for experimental work I have had occasion to self-pollenize individuals of about twenty varieties, and I have, in no case, had to have recourse to any means of pollen preservation. Contrary to the popular idea, I find that the period during which pollen is shed by any one plant extends pretty well over the time between the maturity of its first and last stigmas.

Anthesis in the male inflorescence begins a short distance from the tip of the central axis, and a little later at the tip of each rachis, and the region of maturity of the flowers passes downward along all the axes simultaneously. The period of maturity is further lengthened by the fact that the two flowers in a spikelet do not mature at the same time, and a second wave of maturity and pollen shedding follows the first. Furthermore, the anther does not discharge all its pollen as soon as it is ripe, but lets it sift out slowly. The combined effect of all these conditions is to lengthen the period over which the plant is shedding pollen.

The pistils near the base of the female inflorescence are the first to mature, and their stigmas emerge from the husk and become receptive usually about the time the first pollen is shed by the same plant. Many individuals are found, however, whose stigmas are out before the maturity of the male flowers, and the reverse is also true of many individuals. In most of the kinds commonly cultivated, however, neither of these characteristics seems to be constant for the variety. It is possible that, if the order of maturity of the two inflorescences behaves in true Mendelian fashion, this characteristic has been disregarded in hybridization and selection to such an extent that it has not become fixed for the variety. Self-pollination of an individual is rarely completely prevented in the commoner cultivated varieties by a difference in the time of maturity of the inflorescences.

But, in spite of the fact that self-pollination is possible and actually occurs to a certain extent, it is clear that cross pollination is not only the common occurrence, but is necessary for complete

pollination and the production of well-filled ears, as is shown by a comparison of the ears from isolated plants with those that have been produced where a large number of plants near together were shedding pollen at the same time.

Whether or not cross pollination is necessary for the maintenance of the full vigor of a strain is another question, and one that is by no means settled at present. It is not at all impossible that our different agricultural varieties will ultimately be found to differ in this respect. The maize varieties that we now have are the result of much haphazard hybridization, and nothing short of years of work will ever give conclusive results along this line.

#### FLORAL ABNORMALITIES

It has already been stated that monoecism is the rule, and that the male and female flowers are grouped together in separate inflorescences. But occasionally in probably all types, and often in at least one variety, some of the rudimentary organs are replaced by functional ones, and some usually functional are suppressed. As a result, organs of both sexes may be found in the same inflorescence in any one of three ways or in a combination of these ways:

1. Both sexes may occur in the same inflorescence but not necessarily in the same spikelet.
2. Male and female organs may be found in the same spikelet but not necessarily in the same flower.
3. The flowers may be perfect.

The first type of sex combination is very commonly observed in nearly all varieties of corn. Many writers have mentioned it, and Montgomery (2), especially, has published a number of illustrations of the phenomenon. Its occurrence in the tassel is apparently due to the development of the female instead of the male elements of the spikelets of one or more rachids or, more often, of the central spike. This produces a naked fructification resembling an ear, which Montgomery (2) makes the basis of his theory to account for the evolution of the ear. It has been noted also, as will be more fully discussed later, that some tassel spikelets in pod corn produce only female flowers. In the ear the flowers at the tip are often wholly staminate in structure, although they may never mature pollen. This transposition of sex in the ear

is known in nearly all varieties, but Kempton (14, p. 11) is responsible for the statement that it never occurs in pod corn. It sometimes occurs that the staminate portion of the ear is not at the tip but back some distance, as shown in FIG. 16, where the staminate portion resembles the central spike of a tassel. At least one case has been noted also where a double row of spikelets on an ear was replaced for some distance by spikelets that had the structure of those usually found in the tassel.

In the variety of pod corn that I have been growing the tassels of most plants produce female flowers, and at maturity the tassel is bent sharply downward by the weight of the fruit (FIG. 10). Kempton (14, p. 12) and others have noted the same, and the former observed that such plants produced no ears. The same thing was true for a number of my plants also, but most of them produced ears of the podded type. Examination of these tassels shows that many of the spikelets have one male and one female flower.

Bisexual flowers similar to the typical grass flower, except in the structure of the stigma and some minor points, have been found in both the ear and the tassel of pod corn. It is somewhat doubtful whether or not the stamens in the ear spikelets of my plants produced pollen, but they were of the normal size. In the tassel, however, both parts of the perfect flowers were most certainly functional. On account of the increased length of the glumes in these flowers, however, as in almost all flowers of this pod corn, the stamens are not exerted in anthesis. This introduces a special problem of pollination which has not yet been fully investigated.

The presence of these hermaphrodite flowers in pod corn and occasionally in other varieties, and the occurrence of both sexes in the same inflorescence but not in the same flower have provided the basis of the theory generally accepted that the monoecious flowers of the normal maize plant have developed, by the suppression of parts, from hermaphrodite flowers borne in tassel-like inflorescences by some unknown primitive ancestor.

Montgomery (3, p. 349) mentions an ear of dent corn that had three well-developed stamens with each grain and three small ones in the aborted flower. He says further: "This little abortive

flower can be found in the embryonic stages of development, and usually all trace of its presence is lost except the extra pair of glumes on the posterior side of the kernel. These little stamens, however, indicate that it at one time might have functioned and give us another clue to some of the evolutionary changes that this interesting plant has gone through."

Contrary to this statement, I find, as previously described, that all traces of the aborted flower are not lost but are present *in every female spikelet*, at least in rudimentary form, at the time of fecundation (FIG. 9). Moreover, if three rudimentary stamens in the spikelets of one particular ear give a clue to evolutionary changes, a much better clue must be given by the development of a normal caryopsis from the lower flower of every female spikelet of Country Gentleman sweet corn (FIG. 14).

The structure of the perfect flowers in pod corn, with reference to the order in which the four flowers of a pair of spikelets lost their staminate elements on becoming ear spikelets, has been worked out by Kempton (14, p. 10). He concludes that the first to change was the upper flower of the sessile spikelet, then the upper flower in the pedicelled spikelet, and then the other two flowers in the same order. Many evidences that I have observed in the tassel of pod corn are in accord with these conclusions, but an occasional spikelet with a functional ovule in the upper flower and the stamens of this one and both pistil and stamens of the lower flower aborted would lead to the belief that the entire lower flower may sometimes have become aborted without a previous loss of function by its stamens. In such spikelet, too, the lodicules of the lower flower are almost normal in appearance, while those of the upper flower are very much reduced in size. This indicates the beginning of the line of evolution that has left rudimentary lodicules in the aborted flower and entirely removed them from the upper flower of the ordinary female spikelet. Moreover, more weight must be attributed to evolutionary evidences from spikelets of the ear, which have passed through the process, than to those from tassel spikelets, which may or may not be giving indications that we are interpreting correctly.

The structure of the stamens of these tassel flowers presents a problem that cannot be solved from the standpoint of gross



morphology alone. Guided by size and shape we might select from an ordinary tassel a complete series of stamens represented at one end by a functional organ and at the other by a degree of abortion equal to that which is characteristic of the rudimentary stamens of the normal pistillate flower; and between the two extremes would be possible monstrous forms. It is only when the function of producing mature pollen has been lost that we can say that the flower has ceased to be perfect, and it is probable that, in some cases, this can be determined only cytologically or physiologically.

But the vital point of the whole question, in so far as evolution is concerned, is not the order in which the perfect flowers of a pair of tassel spikelets changed into the present pistillate condition, nor even the occurrence of occasional functional stamens or pistils in flowers of the opposite sex, but in the fact that *every flower of either sex contains either rudimentary or functional elements of the opposite sex*. This is the real indication of primitive hermaphroditism, and the other points only serve to supplement this fact.

#### SUMMARY

1. Normally the maize plant is monoecious.
2. The male spikelet is two-flowered. Each flower has three stamens, two lodicules, and a rudimentary pistil.
3. The female spikelet is two-flowered, but, in most instances, the lower flower is aborted.
4. In Country Gentleman sweet corn the lower flower of the female spikelet regularly functions the same as the upper one. This same phenomenon has been noted in some spikelets of pod corn.
5. The upper female flower has a pistil and three rudimentary stamens but no lodicules.
6. The lower female flower has a pistil, three rudimentary stamens, and two rudimentary lodicules, whether the flower be aborted or functional.
7. Structurally and functionally the silk is a stigma.
8. Pollination is effected by gravity and the wind. A relatively large amount of pollen is produced. Cross pollination is the more common occurrence, but self-pollination is possible and occurs to a certain extent.

9. In flowers of either sex the rudimentary organs of the opposite sex may be replaced by organs of normal appearance. In many instances these are not functional, but pistils are regularly functional in the tassels of some varieties of pod corn.

10. Except in pod corn the glumes do not enclose the caryopsis as in most grasses.

UNIVERSITY OF INDIANA,  
BLOOMINGTON, INDIANA

#### LITERATURE CITED

1. **Harshberger, J. W.** Maize, or Indian corn. Cyclopedia of American Agriculture. Fourth Edition. **2**: 398-402. 1912.
2. **Montgomery, E. G.** What is an ear of corn? Pop. Sci. Mo. **68**: 55-62. *f. 1-14*. 1906.
3. **Montgomery, E. G.** Perfect flowers in maize. Pop. Sci. Mo. **79**: 346-349. *f. 1-6*. 1911.
4. **Baillon, H.** Histoire des plantes. **12**. Paris. 1894.
5. **Bentham, G., & Hooker, J. D.** Genera plantarum. **3**. London. 1862.
6. **Hunt, T. F.** Cereals in America. London. 1912.
7. **Wood, A.** Botanist and florist. New York. 1870(?).
8. **Crozier, A. A.** Silk seeking pollen. Bot. Gaz. **13**: 242. 1888.
9. **True, R. H.** On the development of the caryopsis. Bot. Gaz. **18**: 212-226, *pl. 24-26*. 1893.
10. **Guignard, L.** La double fécondation dans le maïs. Jour. de Bot. **15**: 37-50. 1901.
11. **Poindexter, C. C.** The development of the spikelet and grain of corn. Ohio Nat. **4**: 3-9. *f. 1-11*. 1901.
12. **Sturtevant, E. L.** Notes on maize. Bull. Torrey Club **21**: 319-343. 1894. A similar article by the same author was published as Bull. 57, Bureau of Plant Industry, Washington.
13. **Stewart, A.** The pistillate spikelet in *Zea Mays*. Science, II. **42**: 694. 1915.
14. **Kempton, J. H.** Floral abnormalities in maize. U. S. Dept. Agr. Bur. Pl. Ind. Bull. 278. 1913.
15. **Collins, G. N.** A variety of maize with silks maturing before the tassels. U. S. Dept. Agr. Bur. Pl. Ind. Circ. 107. 1913.

**Explanation of plates 5 and 6**

## PLATE 5

FIG. 1. Male spikelet of Red Cob Cory sweet corn with one flower in anthesis,  $\times 12$ . *G*, glume; *Pa*, palea; *A*, anther of unopened flower; *F*, elongated filament of mature stamen; *O*, opening of anther; *J*, joint of rachilla.

FIG. 2. Male flower of Red Cob Cory sweet corn with its own palea and the other half of the spikelet removed,  $\times 15$ . *G*, glume; *Le*, lemma; *F*, short, thick filament of immature stamen; *P*, rudimentary pistil; *Pa*, base of palea that has been removed; *L*, lodicule.

FIG. 3. Female spikelet of Red Cob Cory,  $\times 10$ . *Sti*, stigma; *SC*, stylar canal; *Sty*, style; *Ov*, ovary; *G*, glumes; *J*, joint of rachilla.

FIG. 4. Female spikelet of Red Cob Cory, with floral bracts removed,  $\times 10$ . *Sti*, base of stigma; *SC*, stylar canal; *Sty*, style; *Ov*, ovary (functional); *Sta*, rudimentary stamen; *P*, pistil of aborted flower; *Sta*, stamen of aborted flower; *G*, *L*, and *P*, scars left by removal of glumes, lemmae, and paleae, respectively.

FIG. 5. Tip of stigma of Red Cob Cory, showing two points and hairs for catching pollen,  $\times 15$ .

FIG. 6. Adaxial side of a segment of the stigma a short distance from the style,  $\times 15$ .

FIG. 7. Same as FIG. 6 but seen from the abaxial side.

FIG. 8. Transverse section of the stigma,  $\times 30$ ; the adaxial side is above. *V*, vascular strands; *H*, place of attachment of hairs.

FIG. 9. Aborted lower flower of female spikelet of Red Cob Cory,  $\times 20$ . *Sta*, stamen; *P*, pistil; *L*, lodicule; *Pa*, palea; *Le*, scar left by removal of lemma.

## PLATE 6

FIG. 10. Tassel of pod corn, bent sharply downward by the weight of the fruits that have developed in it.

FIG. 11. Pairs of spikelets from tassel of pod corn.

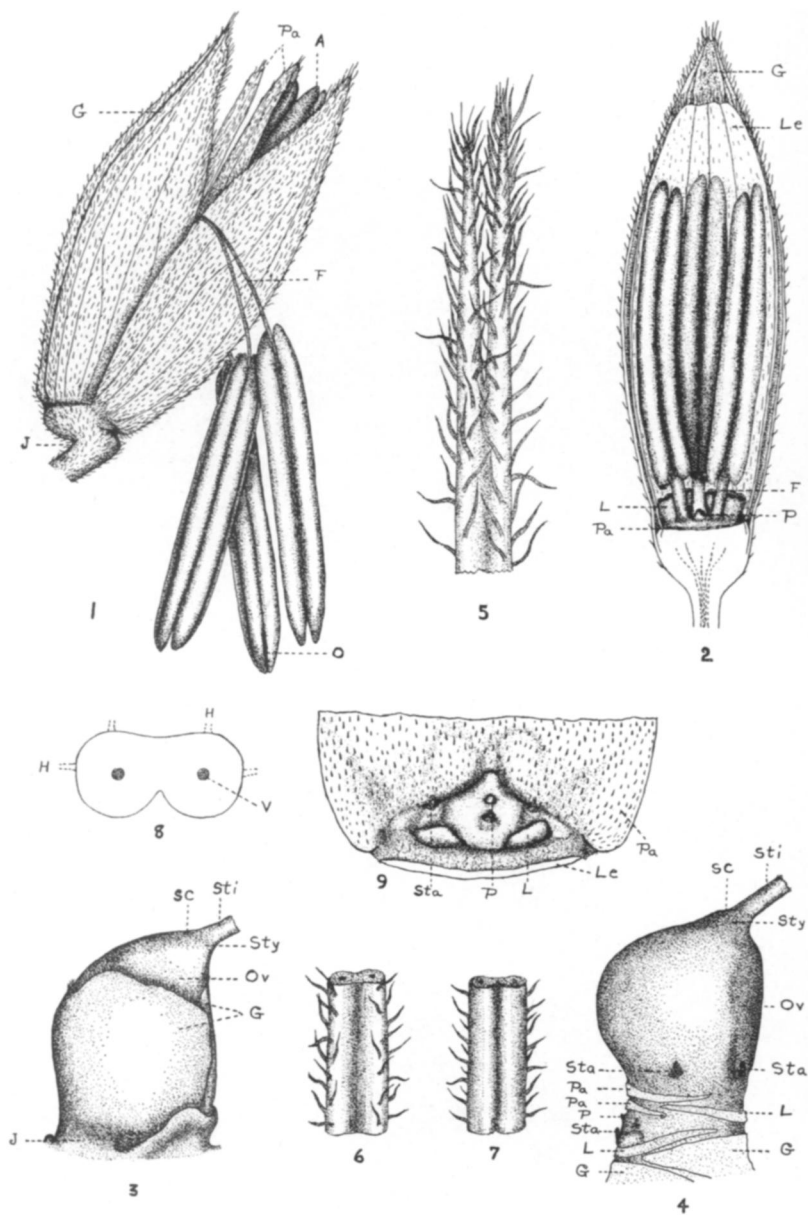
FIG. 12. Pairs of spikelets from ear of pod corn. One spikelet in each pair shown has two fruits.

FIG. 13. Grains of Country Gentleman sweet corn (above), and of Stowell's Evergreen (below).

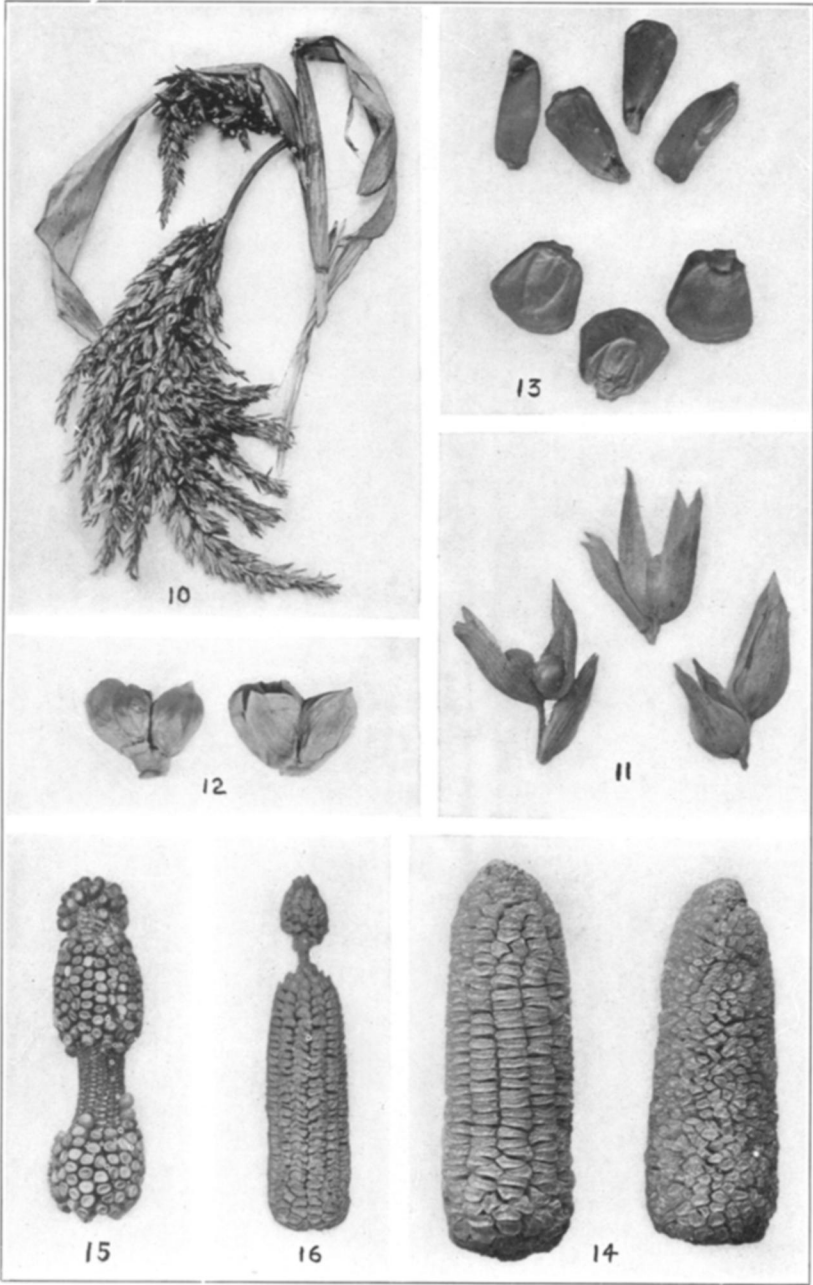
FIG. 14. Ears of sweet corn. Stowell's Evergreen on the left, Country Gentleman on the right.

FIG. 15. Periodic pollination. This ear was bagged after a few silks had come out, and the bag was taken off before all the stigmas had lost their receptivity. The middle portion has no grains because the silks from this part passed their period of receptivity while the ear was protected from pollen.

FIG. 16. Ear of a yellow dent variety. The constricted place back of the tip is staminate in structure.



WEATHERWAX: FLOWERS OF ZEA MAYS



WEATHERWAX : FLOWERS OF ZEA MAYS